WATER RESOURCES RESEARCH GRANT PROPOSAL

Project ID: 2005AZ114G

Title: Chemolithotrophic denitrification: The missing link in the biogeochemical cycle of arsenic

Project Type: Research

Focus Categories: Toxic Substances, Groundwater, Non Point Pollution

Keywords: Arsenic speciation, arsenite, arsenate, iron, microbial oxidation, denitrification, anoxic; groundwater

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Congressional District: AZ05

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Abstract

Microorganisms play a key role in the redox cycle of arsenic, dictating the fate and toxicity of the metalloid in the environment. The respiratory reduction of arsenate (As(V)) to arsenite (As(III)) is a ubiquitous process carried out in reducing anaerobic environments by a diverse group of bacteria. Conversely, in aerobic environments, many bacteria gain energy from the oxidation of As(III) to As(V). The arsenic cycle is closely integrated with the iron cycle, since iron oxides are important sorbents of As(V) in soils and sediments. As(III) adsorbs less strongly to iron oxides and other minerals than As(V) and is generally the more mobile species. Microorganisms can impact the fate of arsenic by their ability to oxidize and reduce iron, resulting in the generation or dissolution of As-sorbents, respectively. The low solubility and diffusivity of O2 in submerged environments limits the depth to which aerobic oxidation of As(III) and ferrous iron (Fe(II)) can occur. Recent evidence indicates that nitrate-reducing bacteria can oxidize

both As(III) and Fe(II) in anoxic environments. The oxygen-independent oxidations of As(III) and Fe(II) could be important links in the arsenic biogeochemical cycle. The objective of this study is to evaluate the importance of chemolithotrophic denitrifying bacteria in the biogeochemical cycle of arsenic. The proposed research will examine the direct microbial oxidation of As(III) with nitrate as electron acceptor, and the microbial oxidation of FeII with nitrate and subsequent adsorption of As(V) by the iron oxides formed. The central question addressed in this proposal is whether anoxic oxidations of As(III) and Fe(II) are ubiquitous process in groundwater and surface waters controlling the mobility of arsenic. The proposal will determine if the conversions linked to denitrification occur at significant rates. Likewise, the study will attempt to identify the diversity of microorganisms involved and the nature of the chemolithotrophic reactions they carry out. Another pertinent question is whether the iron oxides generated by anoxic oxidation of Fe(II) will have the same high capacity for the sorption of AsV as iron oxides generated by aerobic oxidation. Lastly, the project will evaluate the natural attenuation of dissolved As(III) in continuous-flow sediment columns operated under denitrifying conditions in the absence and presence of iron. The project will demonstrate whether nitrate is a key determinant controlling the mobility of arsenic in anoxic environments. These results can be used to improve models for estimating arsenic concentrations in groundwater and surface water. Improved understanding of the ability of nitrate-reducing bacteria to oxidize As(III) and Fe(II) can form the underpinning of bioremediation technologies to prevent further migration of soluble arsenic in contaminated plumes to drinking wells.